Rack-and-Pinion Steering Ratio, Turns and Wheel Effort

Steering ratio from pinion size and steering arm length, turns lock to lock, and steering wheel torque and rim force for a rack force with power assist.

Method: Rack-and-pinion kinematics and statics

Input parameters

Unit system: SI

Parameter	Value	Unit
Pinion pitch diameter	14.500	mm
Steering arm length	140.00	mm
Road wheel lock angle	36.000	°
Rack force needed	6.0000	kN
Steering wheel radius	185.00	mm
Share of rack force from assistance	80.000	%
Steering gear efficiency	85.000	%

Calculated results

Parameter	Value	Unit
Overall steering ratio (centre)	19.310	
Rack travel to lock	82.290	mm
Turns lock to lock	3.6129	
Steering wheel torque	10.235	N·m
Rim force	55.326	N

Notes for this case

• Rack moves (d_p/2) per radian of steering wheel; the road wheel turns about rack travel/arm length, so the centre ratio is 2a/d_p. Turns lock to lock = 2a·sin δ_max/(πd_p). Driver torque = (1 − assist share)·F_r·(d_p/2)/η. Car ratios are about 13–18:1 and 2.5–3.5 turns lock to lock; parking rack forces of 5–10 kN need assistance.

Formula and method

$$i_s = \frac{2a}{d_p}, \quad n_{lock} = \frac{2a \sin \delta_{max}}{\pi d_p}, \quad T_{sw} = \frac{(1 - k_a) F_r d_p}{2\eta}$$

Variables

d_p	Pinion pitch diameter	m
a	Steering arm length	m
δ_{max}	Road wheel lock angle	rad
F_r	Rack force needed	N
r_{sw}	Steering wheel radius	m
k_a	Share of rack force from assistance	-
η	Steering gear efficiency	-
i_s	Overall steering ratio (centre)	-
x_{max}	Rack travel to lock	m
n_{lock}	Turns lock to lock	-
T_{sw}	Steering wheel torque	N·m

F_{rim}	Rim force	N

Method and standards

Steering ratio.

Assumptions and limits

- Constant-ratio rack; arm perpendicular at centre; small linkage effects ignored.

References

Rack-and-pinion kinematics and statics

Report details

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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/automotive/vehicle-dynamics/steering-ratio-effort

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.